

Synergism of Saturn, Enceladus and Titan and Formation of HCNO Prebiotic Molecules

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Saturn as a system has two very exotic moons Titan and Enceladus. Titan, taking in energy from Saturn's magnetosphere, solar UV irradiation, and cosmic rays, can make HCN based molecules as discussed in earlier paper by Raulin and Owen (2002). Space radiation effects at both moons, and as coupled by the Saturn magnetosphere, could cause an unexpected series of events potentially leading to prebiotic chemical evolution at Titan with HCNO from magnetospheric oxygen as the new ingredient. The "Old Faithful" model by Cooper et al. (2009) suggests that Enceladus, highly irradiated by Saturn magnetospheric electrons and thus having a source of chemical energy from radiolytic gas production, has episodic ejections of water vapor, carbon dioxide, and various hydrocarbons into Saturn's magnetosphere. The hydrocarbons do not survive transport through the plasma environment, but oxygen ions from Enceladus water molecules become the dominant ion species in the outer magnetosphere. At Titan, Cassini discovered that 1) keV oxygen ions, evidently from Enceladus, are bombarding Titan's upper atmosphere (Hartle et al., 2006a,b) and 2) heavy positive and negative ions exist in significant abundances within Titan's upper atmosphere (Coates et al., 2007). Initial models of heavy ion formation in Titan's upper atmosphere invoked polymerization of aromatics such as benzenes and their radicals to make polycyclic aromatic hydrocarbons (PAH) (Waite et al., 2007), while a more recent model by Sittler et al., (2009) has raised the possibility of carbon chains forming from the polymerization of acetylene and its radicals to make fullerenes. Laboratory measurements indicate that fullerenes, which are hollow carbon shells, can trap keV oxygen ions. Clustering of the fullerenes with aerosol mixtures from PAHs and the dominant nitrogen molecules could form larger aerosols enriched in trapped oxygen. Aerosol precipitation could then convey these chemically complex structures deeper into the atmosphere and to the moon surface. Ionizing solar UV, magnetospheric electron, and galactic cosmic ray irradiation would provide further energy for processing into more complex organic forms. Further ionizing irradiation from cosmic rays deep in the atmosphere "tholin" molecules are produced with all the molecular components present from which prebiotic organic molecules can form. This synergy of Saturn system, exogenic irradiation, and molecular processes provides a potential pathway for accumulation of prebiotic chemistry on the surface of Titan. Since fullerenes are also thought to exist in interstellar space, similar processes may also occur there to seed molecular clouds with prebiotic chemical species. We will also discuss possible future laboratory experiments that could be done to investigate fullerene formation at Titan and the trapping of oxygen in fullerenes.